

G/I-235
18 October 1957

SOVIET CAPABILITIES IN GEODESY THROUGH 1967

A. Conclusions and Summary

Geodetic operations within the USSR are jointly planned and controlled by two organizations -- one civil (GUOK) and one military (VTU) -- which have complex substructures scattered throughout the country. In the past, geodetic educational institutions have turned out an abundant number of engineers and theoreticians, and today the USSR has no lack of competent geodetic personnel capable of carrying on all essential tasks. First-order horizontal control covers at least two-thirds of the area of the country. The Soviets claim to have the potential capability for adding over 10,000 new standard control stations per year. In 1942-45, the horizontal net was readjusted to the new Krasovskiy ellipsoid; currently the net is again undergoing readjustment, partly because of the conversion of the European satellite nets to the Soviet datum. The Soviets have a strong interest in establishing connections between their datum and both the European Datum and the North American Datum. It is believed that the requirements of the ICBM program for accurate positioning between widely separated points on the earth's surface has given great impetus to theoretical geodesy and gravimetry. The Soviets will undoubtedly exploit the artificial earth satellite for geodetic purposes in order to gain more precise knowledge of the parameters of the earth's size and shape. They are not likely to change their policy of withholding essential geodetic data and topographic maps from the rest of the world as long as present political tensions continue.

B. Organization, Planning, and Control

Basic surveying and mapping of the country at large is centralized in the Chief Administration of Geodesy and Cartography (commonly referred to as GUGK, abbreviated from the Russian form of its name), which works in concert with the Military Topographic Administration (VTU) of the Army General Staff and probably also with the Hydrographic Administration. Other surveying and mapping units function as parts of individual ministries, administrations, or trusts; but all are subject to the centralized plans, programs, specifications, and supervision worked out jointly by GUGK and VTU.

GUGK is a closely integrated organization including, in addition to the conventional technical and administrative units, many functional divisions. One policy-making body, the Collegium, reviews the research activities of the organization and formulates its research programs. Another, the Council, coordinates the activities of the various government organizations (including the military) engaged in cartographic and geodetic work. Among the divisions of GUGK are a central archives for the custody of all data; a unit that publishes geodetic and cartographic literature; a central research institute; and a factory for the production of geodetic and other mapping instruments. GUGK also maintains 12 aerial-photographic and geodetic establishments and 12 cartographic plants for the analysis, compilation, and printing of topographic maps.

The organization of VTU also includes many different divisions--a production service (VTS); a faculty for advanced geodesy at the Engineering Academy; a scientific research institute; an

instrument production plant; 12 topographic units; 7 geodetic units; 3 aerial photographic units; 12 geodetic and cartographic units; and a field training and testing camp.

C. Extent and Adequacy of Present and Future Research Facilities

Research in geodesy and cartography is carried out in many institutions throughout the USSR. In the past 10 years, great impetus has been given to geodetic research by problems arising in connection with (1) the application of aerial photography to mapping, (2) the testing of new electronic surveying methods, and (3) the anticipated geodetic gains to be derived through the use of artificial earth satellites. The Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography (TsNIIGAIK), located in Moscow, is a huge complex organization devoted to all phases of geodetic research. The Soviet Academy of Sciences also has research institutes scattered throughout the USSR, the greatest concentrations of which are around Moscow and Leningrad. Recent reports indicate that a special Institute of Mathematics (under the Academy of Sciences) has been established in Moscow and is doing all the theoretical work connected with the orbits of artificial earth satellites. The Soviets are quick to create new institutes for work on specific problems that do not fit into the existing organization. Current research facilities in geodesy appear to be entirely adequate to handle the heavy load of further readjustment of existing control, along with the many new astro-geodetic investigations occasioned by the orbiting of an artificial earth satellite.

D. Quality, Quantity, and Effective Utilization of Manpower

Soviet geodesy today engages a vast number of workers (estimated at 15,000 to 20,000) representing all levels of training and experience from field work through abstract theoretical research. During the past 40 years, strong government support has attracted many young people to geodesy as a life profession. Exceptional students are given special encouragement and inducement to develop their capabilities to the utmost. The number of women performing laboratory tasks and even surveying in the field is surprisingly large. The established training system appears to be providing sufficient manpower to meet the current need for geodesists since high-level Soviet sources have indicated that there is no lack of competent geodetic personnel in the USSR today. Soviet theoreticians working on the figure of the earth and on gravimetric problems are recognized throughout the world as being among the topmost authorities in their profession. In no other nation does there seem to be such avid interest in advancing geodetic and gravitational theory to meet the challenge of determining still more precisely the values of the parameters which relate to the size and shape of the earth.

E. Soviet Objectives, Major Achievements, Trends, and Future Capabilities in Basic Research

1. First-order Control

The Soviets are currently extending first-order horizontal control from the main east-west net in the southern part of Siberia northward along the principal river valleys to the Arctic. The ultimate objective is complete coverage of the USSR. More than two-thirds of the area of the USSR is now provided with

first-order control, and standard triangulation stations (first- and second-order) now number more than 320,000. Control in the remaining unsurveyed part of Siberia can be established at any time within the next 10 years as the need for it arises. The Soviets claim to have the instruments and manpower required to add more than 10,000 new triangulation stations per year. As it now stands the Soviet net is the most recent and one of the largest of the world's principal horizontal control nets. It represents a major theoretical and practical geodetic achievement, accomplished very largely within the last 40 years. Soviet horizontal control was readjusted in 1942-45 and was referenced to the new Krasovskiy ellipsoid by a new projection method for the transfer of points from the earth's surface to the ellipsoid. Relative positioning accuracy between widely separated points is estimated at 1:100,000. Another general readjustment of first-order control is apparently now in progress and should be completed within a year or two.

2. Krasovskiy Ellipsoid

The Krasovskiy ellipsoid, adopted for the Soviet Union in 1946, fits the vast area of the USSR much better than the Bessel ellipsoid, which was abandoned. The calculation of the new ellipsoid was accomplished by the Soviets before World War II. They had examined the question of the earth's triaxiality and decided that the biaxial ellipsoid approximated the geoid closely enough for practical purposes. The Soviets are keeping a very watchful eye upon all geodetic work elsewhere in the world that might contribute to a refinement in the values for the earth's semi-major axis and flattening. In the years immediately ahead, the range of uncertainty connected with these values

should be narrowed. A variety of new celestial methods, which are now being tested, will provide the geodesist with different means of approach to the problem. The Soviets, however, apparently have no special advantage over the West in the application of celestial methods to the determination of a better "best fitting ellipsoid."

3. Control Nets of European Satellites

The integration of the geodetic nets of the European Satellites with the geodetic system of the USSR has been in progress since 1952. Complete integration by 1959-60 is a major Soviet objective. Most of the field work has already been done. The whole Soviet Bloc in Europe will thus be referenced to a single geodetic datum with the initial point at Pulkovo in the USSR. This conversion to a unified system has introduced small changes in the geodetic coordinates of control points throughout Satellite areas. Maps that follow Soviet cartographic standards and are based on the new coordinates are now being prepared. For East Germany, the topographic series at 1:25,000 is almost completed. Although the conversion to the Soviet geodetic system satisfies the immediate need for uninterrupted large-scale map coverage of the European Bloc area, a program of more rigorous mathematical readjustment of the Sovbloc first-order control is definitely planned and probably will be carried out during the next 10 years.

4. Connection with the European Datum

With the establishment of a single datum for all Sovbloc areas in eastern Europe, the way became clear for a possible geodetic connection with the recently readjusted European Datum west of the Iron Curtain. Soviet geodesists are thoroughly familiar with the readjustment of the

European Datum that has been carried out by US and West German geodesists. The new European Datum has been generally accepted by the countries involved, although it is realized that there are compromising inaccuracies in some of the older triangulation nets. Western Europe now has a unified geodetic system to which the Soviets can make a theoretical tie. We believe that a major objective of the Soviets is the resolving of the differences between the two datums in order to obtain relative geodetic positions of far-removed points on both sides of the Iron Curtain. The geodetic positioning accuracy required for the launching of intermediate- and long-range missiles to all parts of Europe can be secured only after a connection is made between the two datums.

5. Bering Strait Connection

For many years, the Soviets have dreamed of a connection between the Soviet and North American datums across the Bering Strait. It seems probable that the Soviets already have made a preliminary connection by aerial photography, or they may covertly have made direct observations. [REDACTED] indicated that by about 1960 the Soviets would be interested in making the connection jointly with the United States. A tie across the strait would improve the relative positioning accuracy of Soviet launchings against US targets. Any joint US-USSR operation to make the Bering Strait geodetic connection would be distinctly to the advantage to the USSR unless an agreement is made for the exchange of the first-order control data covering areas extending several hundred miles on either side of the strait. We consider Soviet interest in the Bering Strait connection an indication that ^{Soviet} first-order control now extends to the strait or will within a few years.

25X1X4

6. Artificial Earth Satellites

The artificial earth satellite successfully launched from the USSR on 4 October 1957 was the first of possibly a dozen earth satellites that the Soviets will attempt to launch for scientific purposes during the International Geophysical Year. So far, the Soviets have not revealed the nature of any gravity experiments to determine directly the variations in the earth's exterior gravity field that they might attempt through the use of a satellite. They are confident, however, that the earth satellite will eventually provide a means of determining the gravity anomalies and flattening of the earth. We believe that the study of earth satellite orbits will, indeed, eventually lead to geodetic gains concerning the earth's gravity field. At present the problem seems to be twofold: first, the satellite must be established in a nearly circular orbit--preferably several thousand miles above the earth's surface and must be trackable by optical or other means; second, many accurate determinations of the satellite's position must be made from stations all over the earth so that a precise orbit over a selected period of time can be computed. It is from the analysis of the precisely determined orbit that local gravity anomalies and the earth's flattening can be obtained. The critical operation is the timing and accuracy of the observation of the satellite's position. Since Soviet observations, as far as is known, are limited to a network of stations within the Sino-Soviet Bloc, the Soviets would have to rely upon observations by other nations, chiefly from the United States net throughout the world.

We believe that improvement in the relative positioning of the large continental horizontal-control nets of the world will be among

the first of geodetic gains to be derived from earth satellites. This can be accomplished by simultaneous observations of the satellite from widely separated stations. Despite continued Soviet reluctance to cooperate in the planning of earth satellite programs for geodetic purposes, we believe the USSR will derive no greater geodetic gain than the US from earth satellite analysis during the next 10 years.

7. Communist China

Not much is heard of geodetic progress in Communist China. Field equipment from the USSR and East Germany has been sent into the area for carrying on the usual operations of surveying and leveling. Undoubtedly a program fashioned after the Soviet pattern will be developed and will eventually result in dependable geodetic control for China. Thus the Soviet datum will in time embrace the greater part of the Asian continent. Geodetic personnel has been exchanged between Communist China and the USSR, and the whole geodetic operation in China is probably under close surveillance by top Soviet geodesists. The Soviets have probably made gravity observations to considerable depth inside Communist China in order to facilitate the determination of geoidal profiles and undulations across the border.

8. Gravity Determinations

More than any other country, the Soviet Union has utilized the extensive existing gravity coverage of the country to provide deflection angles and geoidal heights in the establishment of horizontal control. Much stress is placed upon determining by gravimetric methods the components

of the deflection angle at the initial point. The program calling for 1 gravity observation per 1,000 square kilometers, or a total of more than 20,000 observations in the USSR, has long been completed. Gravity coverage of the Soviet Union, therefore, is uniform and complete.

Thousands of observations have also been made at sea with pendulum apparatus of the Vening Meinesz type. Gravity analysis provides one method of determining the flattening of the earth, provided representative data from all over the earth are available. The Soviets are seeking gravity data wherever observations are known to have been made. Soviet political leaders, however, regard gravity data as having military significance. Consequently, Soviet scientists who individually favor an exchange of such data with the West are completely overruled, and no gravity data are released outside the USSR.

It seems probable that, within a few years, methods now under development will facilitate quicker and more accurate determinations of gravity at sea. The Soviets are known to be working on apparatus for such measurements, and they also are considering the possibility of measuring gravity in airplanes. The variation of gravity with altitude must be studied in conjunction with the flight of long-range ballistic missiles. The Soviets have made many gravity determinations throughout the Arctic area and at present are including gravity measurements with other IGY observations taken in Antarctica.

9. Tests with Electronic Distance-Measuring Apparatus

Soviet geodesists have studied the use of electro-optical apparatus for distance measurement in checking the sides of the horizontal control net. Their method of modulating light waves by parallel Kerr condensers is similar to that employed by the Bergstrand geodimeter, but they have made some modifications which permit measurements to be taken in the brightness of day. In 1954, Soviet work on the velocity of light in vacuo yielded a value of $299,793.9 \pm 1.0$ km/sec, which is about 1.4 km/sec higher than the average of several recent determinations by Western observers. We believe that in the years immediately ahead, the Soviets will pursue to the utmost the development of electronic and optical apparatus for distance measurement as an essential preliminary to any present major readjustment of their first-order net.

10. Soviet Policy of Withholding Geodetic Data

Recognizing the military significance of positional and gravimetric data, especially in attaining target accuracy for the ICBM, the Soviets over the past 20 years have persistently withheld all geodetic data and topographic maps of the USSR from other nations of the world. They have thus improved their defense capability in the event of war by denying to other nations the materials most necessary for the planning of offense against the Soviet Union. The principle of wide and unrestricted dissemination that has hitherto governed scientists in the exchange of scientific data has been sidetracked by Soviet political and military leaders as being secondary to considerations of defense.

Individual Soviet scientists have hinted recently that the USSR will soon relax its controls and allow the release of geodetic and gravimetric data pertaining to the Soviet Union. Evidently a struggle has been going on inside the country between the scientists and the military over the question of the release of scientific data. The military definitely have the upper hand in this matter. We believe that Soviet policy of withholding geodetic data and topographic maps will continue in the years ahead -- as long as international tensions remain at or near their present level.

F. Satellite and Chinese Communist Support in Basic Research

Theoretical support to Soviet geodesy is contributed by geodesists from East Germany, Poland, Czechoslovakia, and Hungary whose research emulates the Soviet interest in further refining the parameters of the earth. The very sizable program of conversion to the Soviet geodetic system, which confronts all the satellite countries, has occupied the attention of their geodesists almost completely. There is no indication of geodetic research by Communist China.

G. Gaps in Intelligence in Production of This Monograph

The most acute intelligence need is for recent large-scale maps of the Soviet Union and Satellite countries. Other gaps in our intelligence on Soviet geodesy and gravimetry, as they affect in one way or another the ICBM, include lack of information on the following:

(1) Soviet estimate of the relative geodetic positioning error at the target for the ICBM.

(2) Soviet estimate of the potential target error due to gravity anomalies along the flight path of the ICBM.

- (3) The possible existence of a Soviet current geodetic connection across Bering Strait.
- (4) Soviet methods of effecting intercontinental ties when different geodetic datums are involved.
- (5) Soviet correction factors in making the connection with the new European Datum.
- (6) The present and future Soviet program for gravity observations at sea in Soviet submarines.
- (7) The organizational structure of Soviet geodesy, both military and civil.